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TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 482

THE EFFECT OF SPRAY STRIPS ON A MODEL OF THE P3M-1 FLYING-BOAT HULL

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SUMMARY

This note presents the results of a series of tests made in the N.A.C.A. tank on a one-sixth full-size model of the hull and side floats of the Navy P3M-1 flying boat for the purpose of finding a method of reducing the amount of spray thrown into the propellers of this craft when taking off and landing.

The model was tested without spray strips and with five different spray-strip arrangements. The best arrangement was an improvement over the bare hull with no spray strips, but the improvement was not sufficient to be satisfactory with the propellers in the designed position.

INTRODUCTION

Take-off tests of the P3M-1 flying boat showed that, as constructed, it threw large quantities of spray while taking off and landing, and that enough spray to cause rapid erosion of the propeller tips went through the propeller disks. A spray strip of special form was fitted along the chine of the main hull, but this apparently did not improve matters, and it was reported that the time required to take off was increased.

The Committee had conducted an extensive series of tests on a model of a somewhat similar flying-boat hull with different spray strips. Since in these tests the spray strips were effective, the Bureau of Aeronautics, Navy Department, requested that the Committee investigate the possibility of controlling the spray produced by the P3M-1.

Five different sets of spray strips were attached to a one-sixth full-size model of the hull and the effect of each arrangement on the spray, resistance, rise of center of gravity, and trim angle was observed in routine tank tests. The model was also tested without spray strips as a basis for comparison. Included in the series was a reproduction of the spray strip tried by the Navy. As the worst spray condition occurs at low speeds, the tests were not carried to get-away speed on all the arrangements.

The tests were made in the N.A.C.A. tank, Langley Field, Va., between November 1932 and March 1933.

APPARATUS AND METHOD

The Model

The model included the main hull and the side floats (fig. 1). A crosspiece was secured on top of the main hull and extended on each side to provide a stout support for the floats. The struts between the main hull and the floats were simulated by 3/16-inch-diameter brass rods, and the swings of the tips of the two propellers over their lower quadrants were indicated by curved rods.

The models of both the main hull and the side floats were made of laminated mahogany, carefully smoothed, and were given several coats of gray enamel. The tolerance on the dimensions of the model was ±0.02 inch.

It was necessary to cut down the forward part of the main-hull model to allow room for the towing gear to be attached so that the towing pull would be applied at the specified center of gravity. Figure 2, which gives the lines of the main hull and side floats, shows how the main hull was cut down.

The following table lists the arrangements tested:

Model no.	Side floats	Spray-strip arrangement
18	none	none
18-B	"	B
18-C	"	C
18-CS	S	C
18-DS	S	D
18-S	S	none
18-SA1	S	A1
18-SA	S	A

The Spray Strips

The spray strips were of two types as shown in figure 1. One type (spray strips B, C, and D) was made of 0.032-inch sheet brass, attached to the side of the model with screws and bent to the desired angle below the horizontal. The second type (spray strips A and A1) reproduced the form of the strip tried by the Navy on the full-size boat. It was made by moulding pattern wax on the bottom of the model.

Spray strips were fitted on the forebody only. Spray strips A1, B, C, and D extended between a point 5 inches aft of the bow, and a point 13-21/64 inches forward of the step. They were terminated at the latter point to allow room for the beaching gear designed for the flying boat. In arrangement D a short piece, which extended back to the step, was placed aft of the space required for the beaching gear. Spray strips were also fitted on the inboard sides of the side floats in this arrangement. Spray strip A (fig. 3) represented the arrangement tried on the full-size machine and extended between a point 11 inches aft of the bow and a point 13-21/64 inches forward of the step.

Method of Testing.

Tests were made by the hydrovane method (reference 1) with the small towing gear. The usual measurements of resistance, rise, trim angle, and trimming moment were taken. The gear was attached to the model with the pivot about which the model trims, placed at the specified center of gravity for normal load (15,955 pounds full size or, Δ_0 = 74 pounds model load). The model was balanced to give the correct center of gravity longitudinally, but no attempt was made to balance it vertically.

To supplement observations of the spray, simultaneous photographs were taken by two cameras mounted on the carriage, one forward of the model on the left side, the other above and about 1 foot to the left of the center line.

Program of Tests

The model of the main hull (Model 18) was first tested alone with no spray strips. Two arrangements of spray strips were then tried on the main hull alone (Models 18-B and 18-C). The side floats and propeller arcs were then added and the model tested without spray strips (Model 18-S). The arrangement of spray strips used in Model 18-C was tested on the complete model as Model 18-CS. A third arrangement of spray strips at a lesser angle, φ, was tested on the complete model as Model 18-DS. The type of spray strip was then changed to simulate that used on the full-size hull and two arrangements, differing only in length, were tested as Models 18-SA1 and 18-SA.

RESULTS AND DISCUSSION

Spray Characteristics

A sufficient number of photographs to show the worst spray conditions are reproduced in figure 4. The following remarks, however, are based largely on the observer's notes rather than on the photographs because of the difficulty of interpreting photographs. Water after being deflected by the spray strips appeared white and photographed more clearly than the sheet of water coming directly from the hull bottom.

On Model 18-S it was observed that at model speeds between 10 and 12 feet per second (24 and 29 feet per second, full-scale) the bow blister came up within about 1-1/4 inches (7-1/2 inches, full-scale) of the propeller disks; about 6 inches (3 feet, full-scale) forward of the propellers the blister came up to about the same level as the bottom of the propeller disks. Between 14 and 20 feet per second (34 and 49 feet per second, full-scale) the blister struck the sides of the side floats near their sterns.

Spray-strip arrangement B deflected the spray down at too steep an angle. The spray rebounded higher than the blister rose when there was no spray strip (Model 18-S).

Spray-strip arrangement C gave similar results although the water did not rebound quite so high. The water rebounded to about the same position relative to the propellers as the blister on Model 18-S. The side floats were protected somewhat, but at speeds around 15 feet per second (37 feet per second full-scale) they were struck by the spray coming from those parts of the chines of the main hull where the spray strips were omitted to allow room for the beaching gear.

Because of the decrease in the downward angle ϑ, in spray-strip arrangement D the water did not rebound so high. At the propellers the rebounding spray rose to within about 1-3/4 inches (10-1/2 inches, full-scale) of the bottom of the tip circle, or 1/2 inch (3 inches, full-scale) lower than the blister from the bare hull. Forward of the propellers there was still more improvement, the blister coming up very little higher than at the propellers. At a speed of about 15 feet per second (37 feet per second, full-scale) the water came through the gaps left in the spray strips for the beaching gear and struck the side floats. It is doubtful if the part of the spray strips extending aft of this gap is of any value.

The spray strips on the inboard sides of the floats with this arrangement seemed to be of little use. The side floats were found to contribute very little to the troublesome spray.

Spray-strip arrangements A and A1 gave very nearly the same results as D. The only difference between A and A1 is the extra piece extending forward to the bow on A1. In the tank tests this portion was out of the water while the spray was the worst, but it is probable that, in rough water, it would help keep down the spray from waves. The tank, at present, has no facilities for producing waves of sufficient magnitude to be of any value in the study of such a condition.

General Characteristics

Figures 5 to 12 are curves of resistance, trim angle, rise of center of gravity, trimming moment, and load/resistance plotted against speed. These curves show the effect of the spray strips on the values which affect take-off time and length of take-off run.

As no accurate method of deducting the wind resistance of the model has been developed, it is included in the curves of the water resistance. The wind resistances of the towing gear and of the beam that holds the side floats have, however, been deducted.

Moments that tended to raise the bow were considered positive. The small positive trimming moment shown on the curves in the "free-to-trim" condition exists because the center of gravity of the model was lower than the pivot of the towing gear.

It is estimated that the results obtained are accurate within the limits given below:

Resistance	±0.1 lb.
Trim angle	±0.1°
Rise	±0.1 in.
Trimming moment	±1.0 lb.-ft.
Speed	±0.1 f.p.s.

A few points on the curves lie outside this range, but these are usually at critical points where a perfect check of the results would be impossible even with apparatus having no error.

The curves show only small differences for the various changes. The addition of the side floats to the main hull increased the resistance slightly and reduced the maximum trim angle in the free-to-trim condition. All the spray strips tended to reduce the hump resistance slightly. The model tests gave no indication of an increase in take-off time due to spray strip A, as was suggested in the reports on the performance of the full-size craft, but the model tests with this spray strip were not carried to get-away speed.

CONCLUSIONS

It is concluded that either spray-strip arrangement A or D would reduce the amount of spray which now goes through the propellers, but that this reduction would not be be enough to be satisfactory. Apparently the problem cannot be solved satisfactorily by means of spray strips, with the propellers at the specified location.

The take-off time should not be increased by arrangement D.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., October 19, 1933.

REFERENCE

1. Truscott, Starr: The N.A.C.A. Tank - A High-Speed Towing Basin for Testing Models of Seaplane Floats. T.R. No. 470, N.A.C.A., 1933.

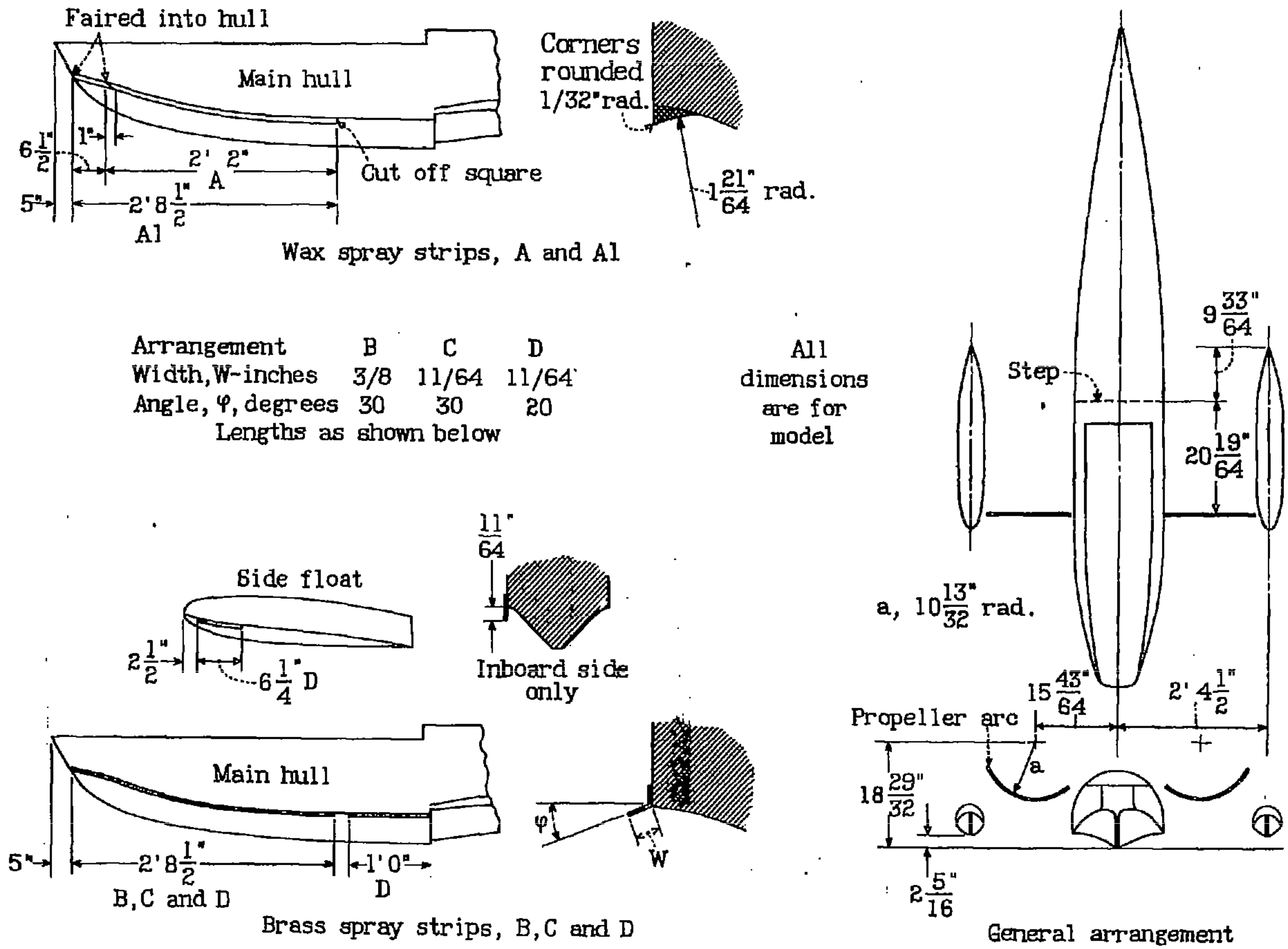


Figure 1.- Spray strips and general arrangement of the P3M-1 model (1/6 scale).

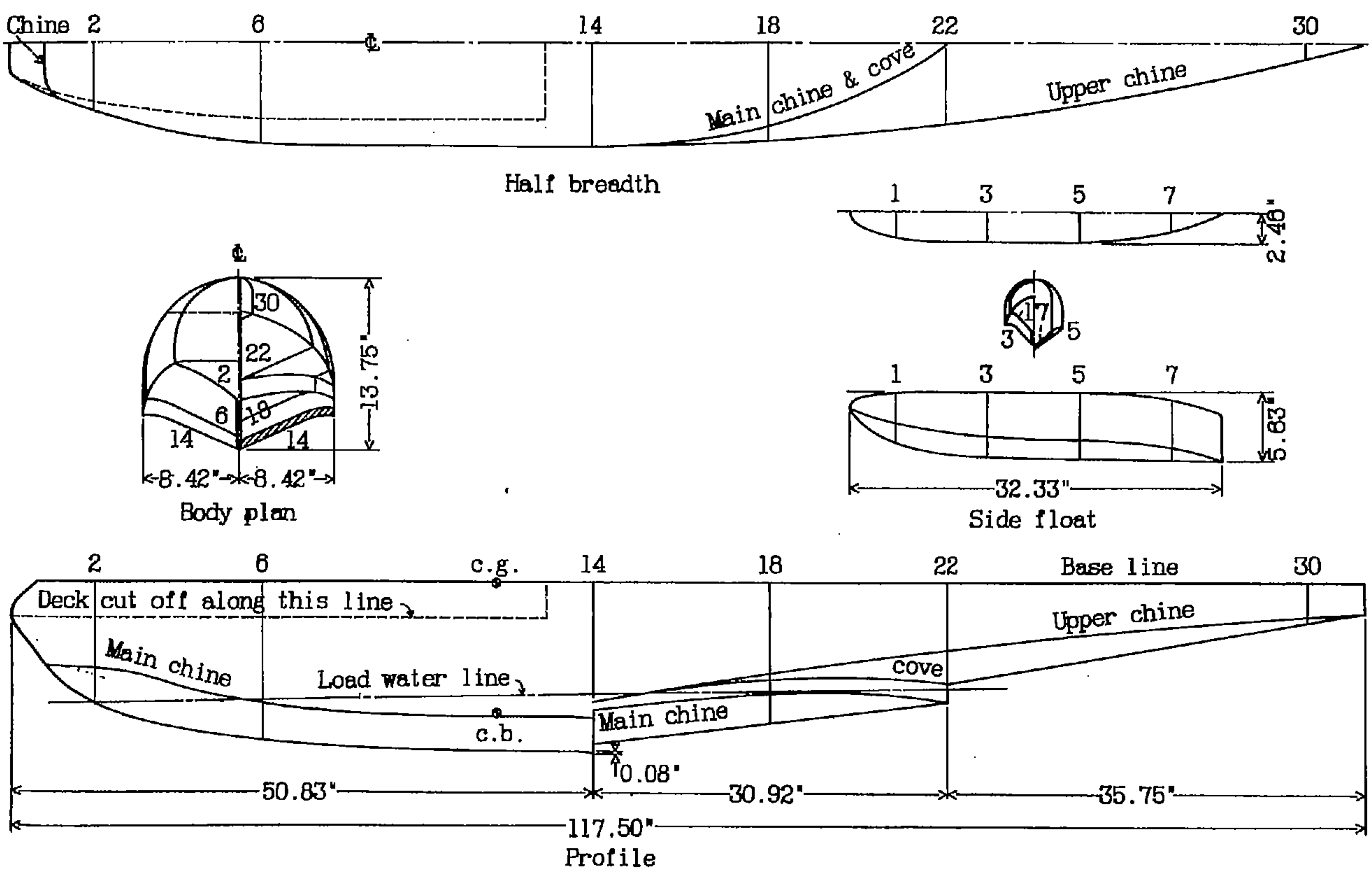


Figure 2.- Main hull and side float lines of the P3M-1 model (1/6 scale).

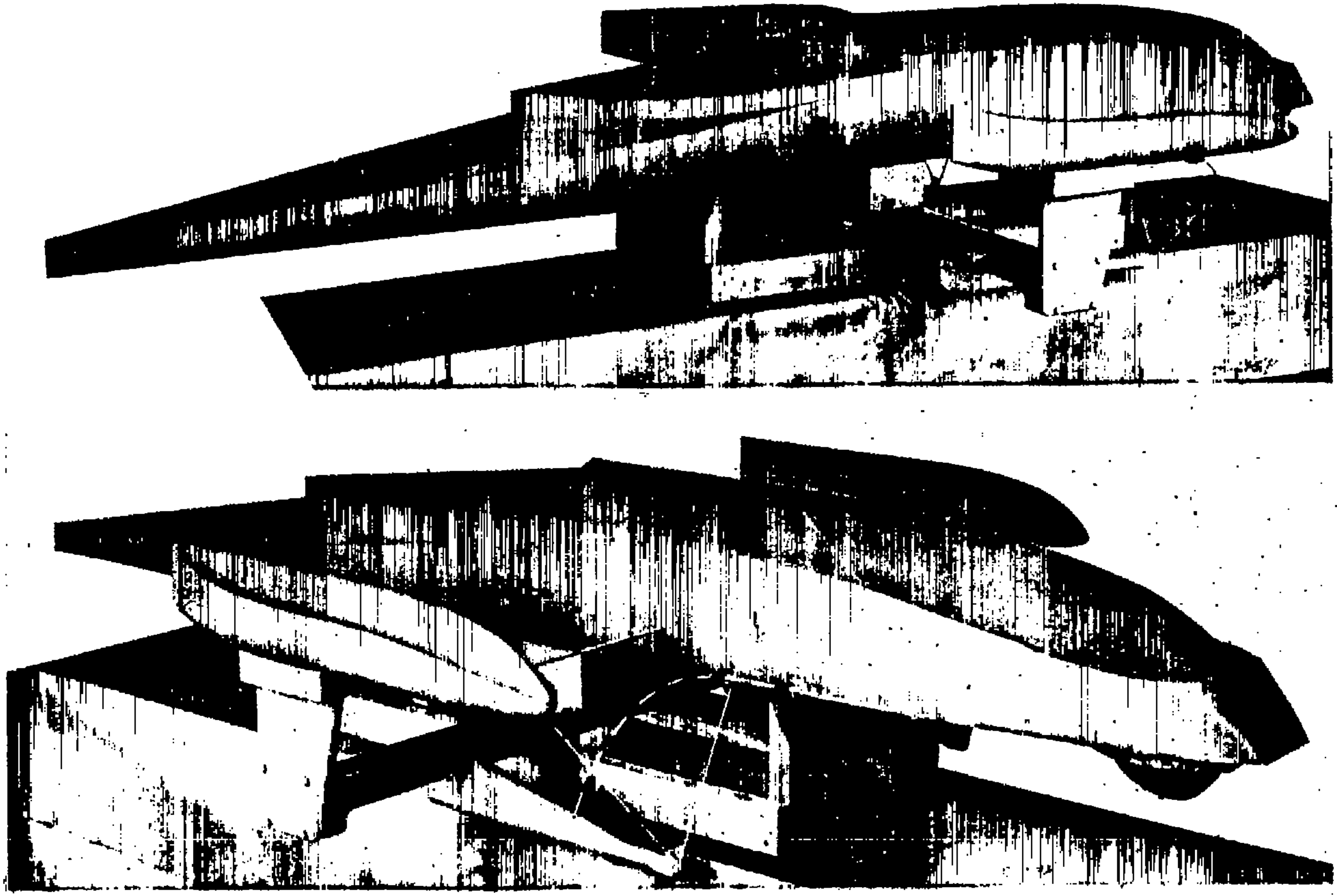
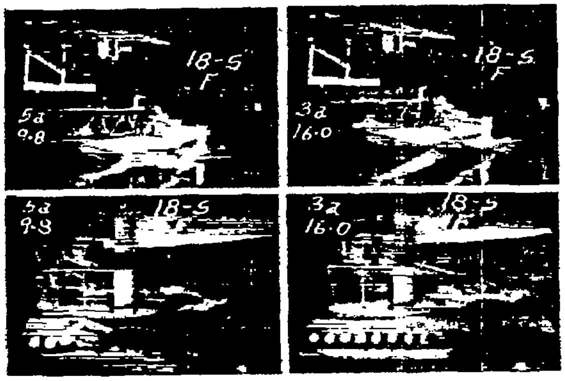
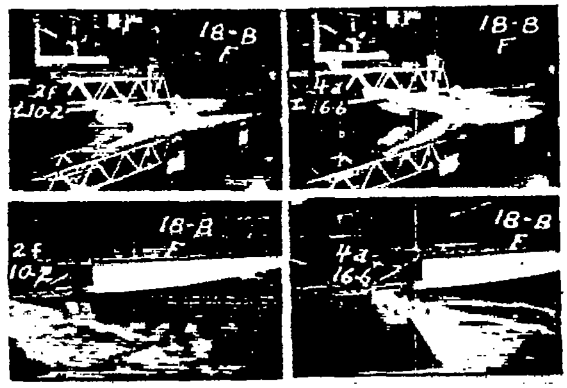


Figure 3.- Photograph of Model 18-SA.



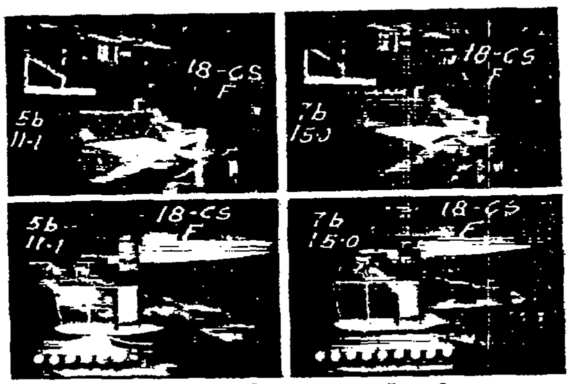
9.8 f.p.s. 16.0

Model No. 18-S



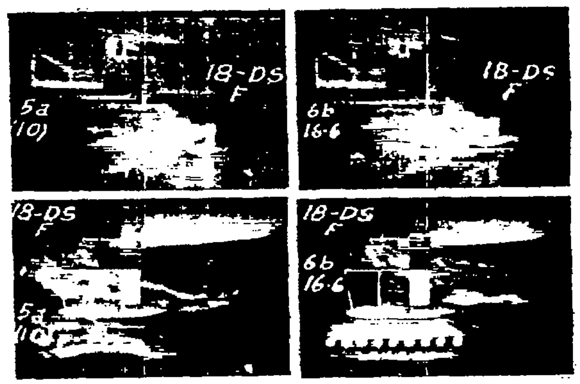
10.2 f.p.s. 16.6

Model No. 18-B



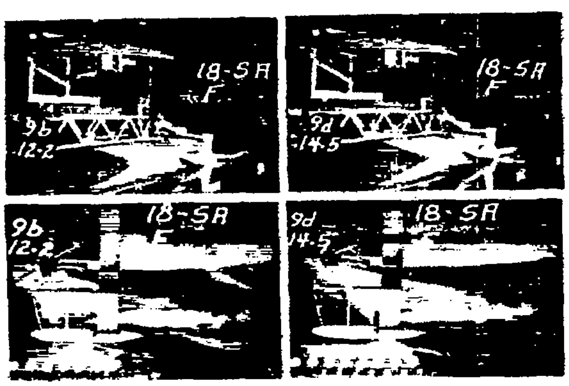
11.1 f.p.s. 15.0

Model No. 18-CS



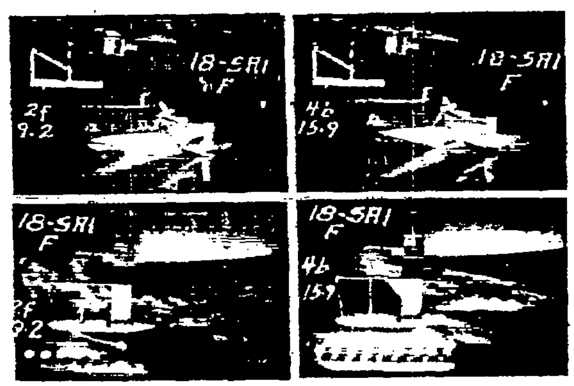
10.0 f.p.s. 16.6

Model No. 18-DS



12.2 f.p.s. 14.5

Model No. 18-SA



9.2 f.p.s. 15.9

Model No. 18-SA1

Note: Model is free to trim in all photographs

Figure 4. - Spray photographs taken during tests on the P3M-1 model.

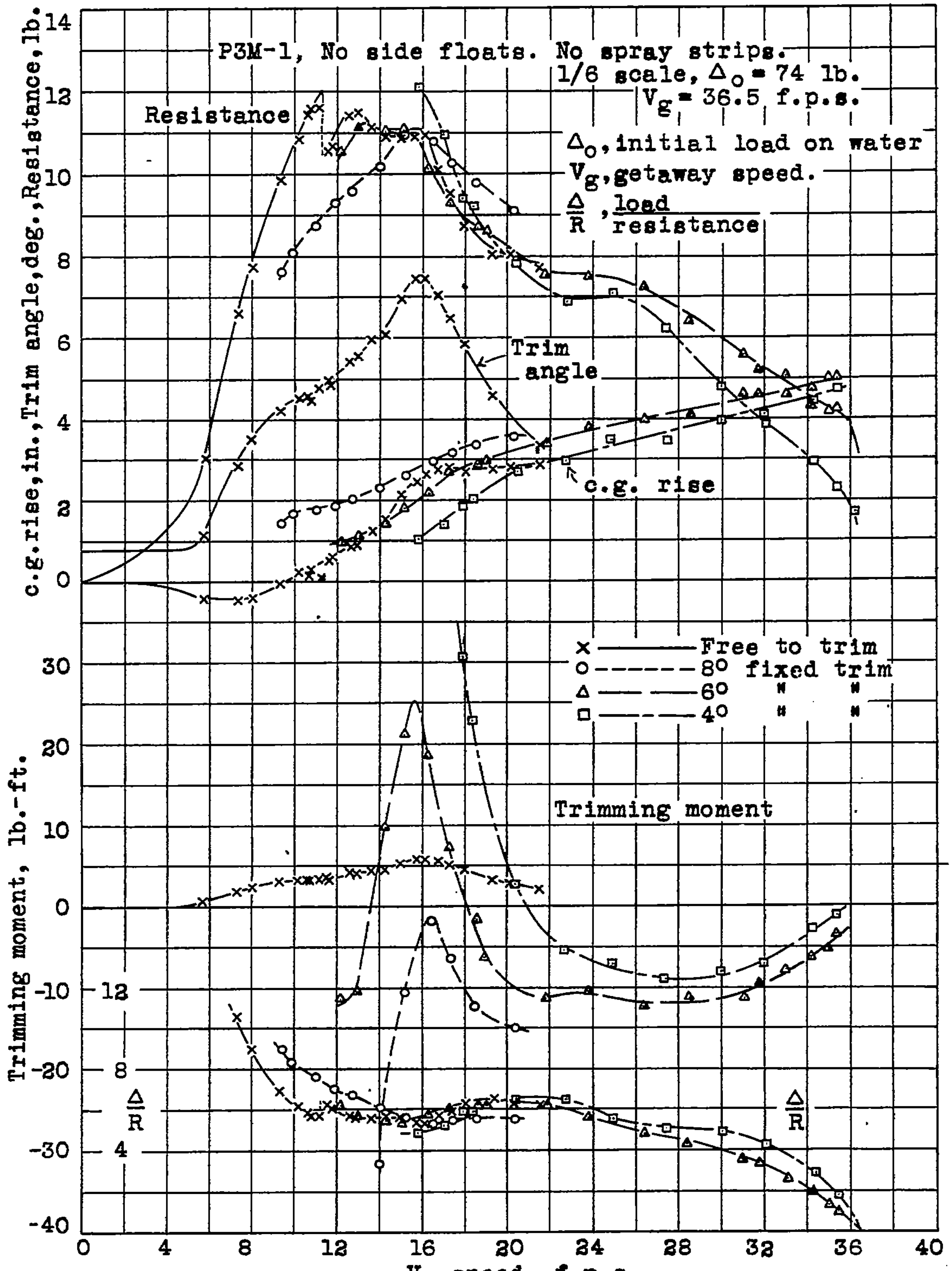


Figure 5.- Water characteristics of model 18.

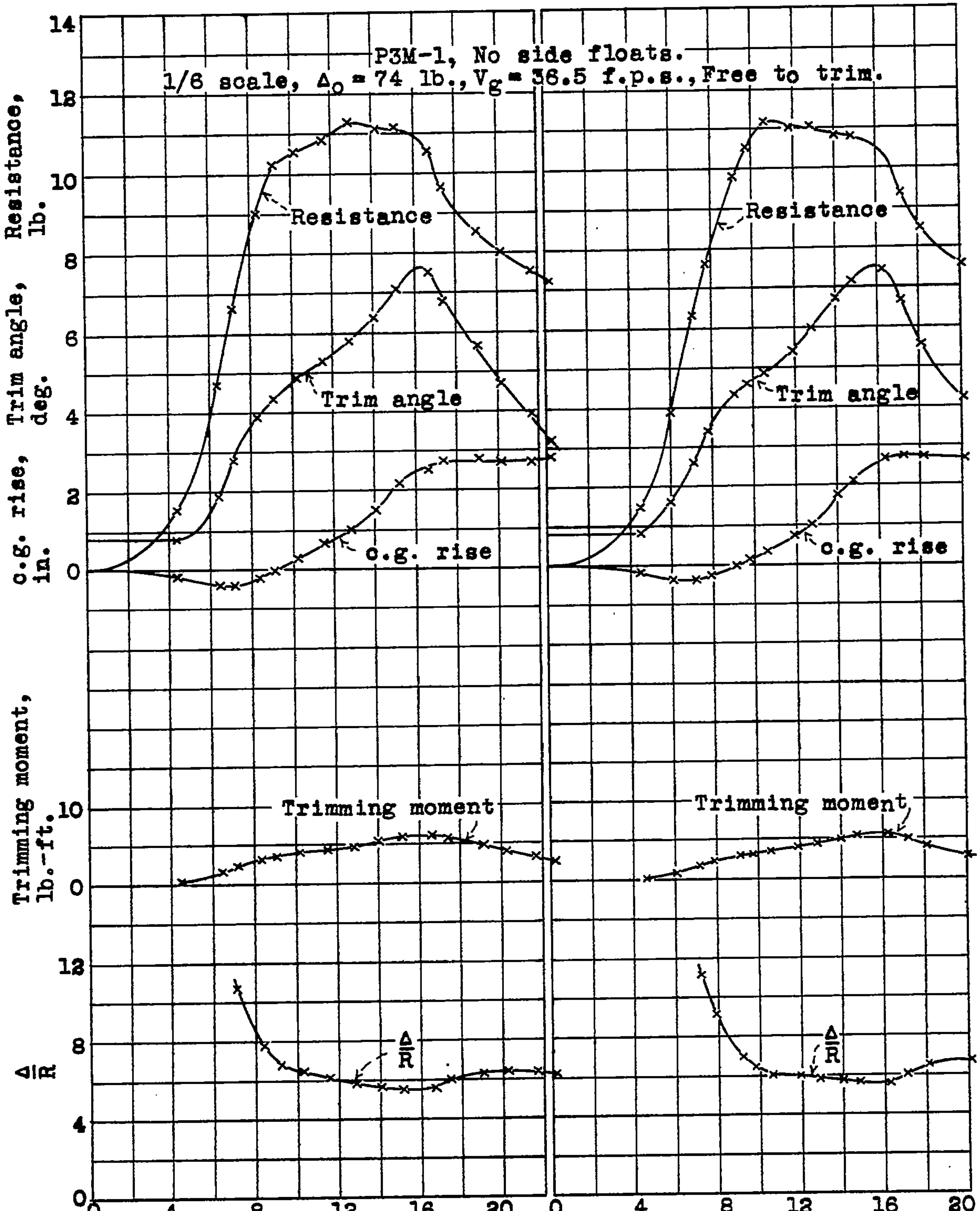


Figure.6.- Water characteristics of model 18-B, with spray strip B.

Figure 7.- Water characteristics of model 18-C, with spray strip C.

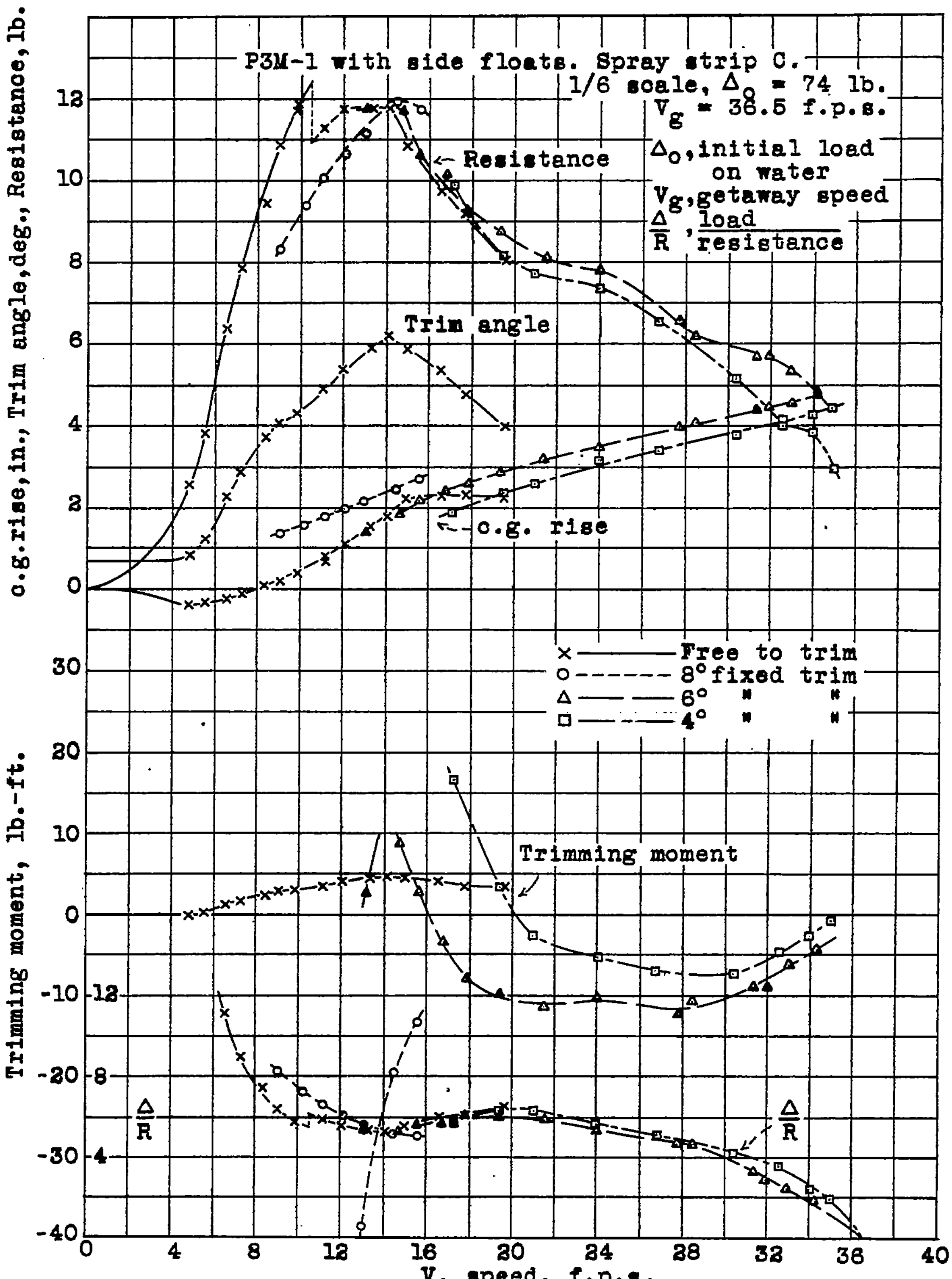


Figure 8. - Water characteristics of Model 18-OS.

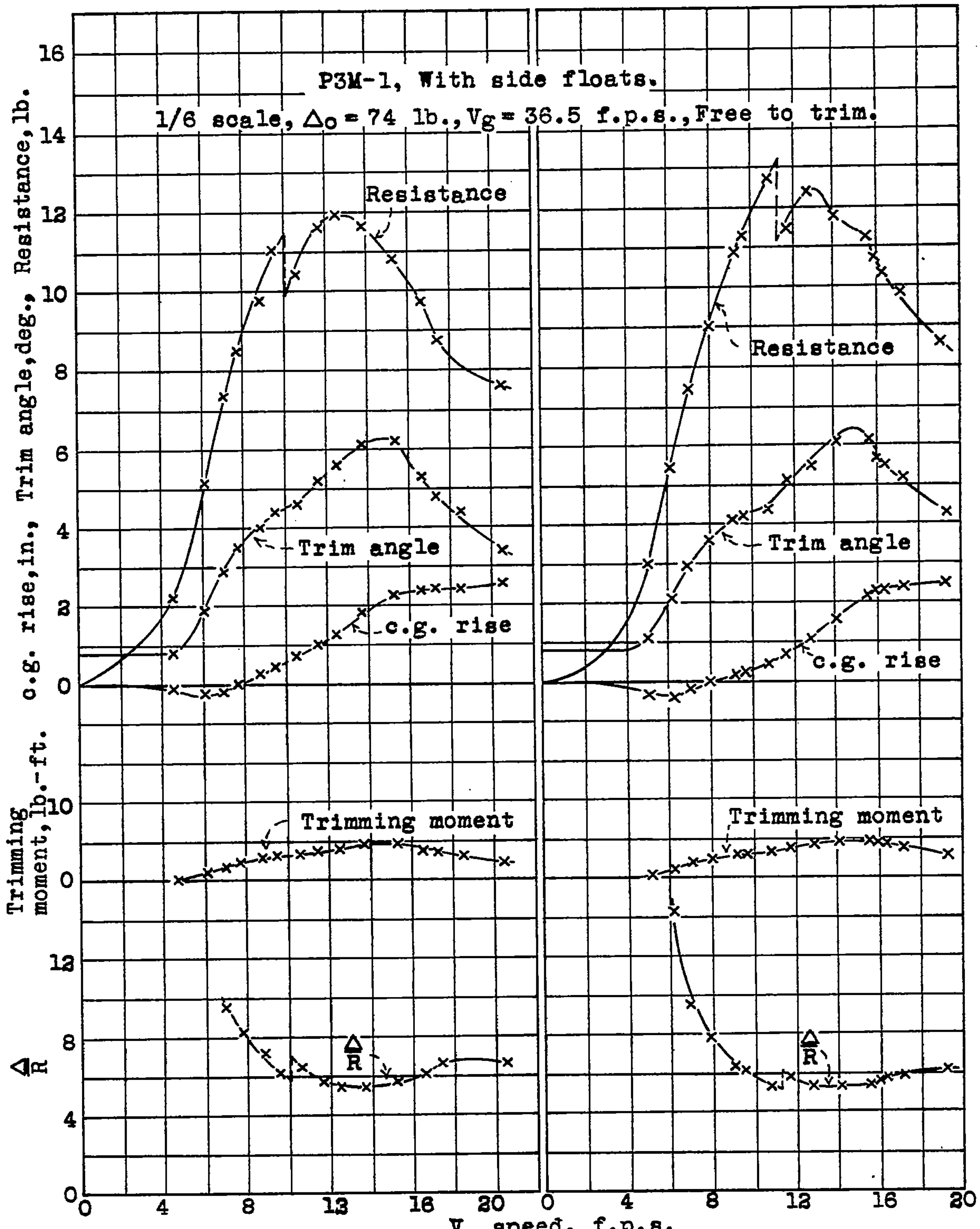


Figure 9.- Water characteristics of model 18-DS, with spray strip D.

Figure 10.- Water characteristics of model 18-S. No spray strips.

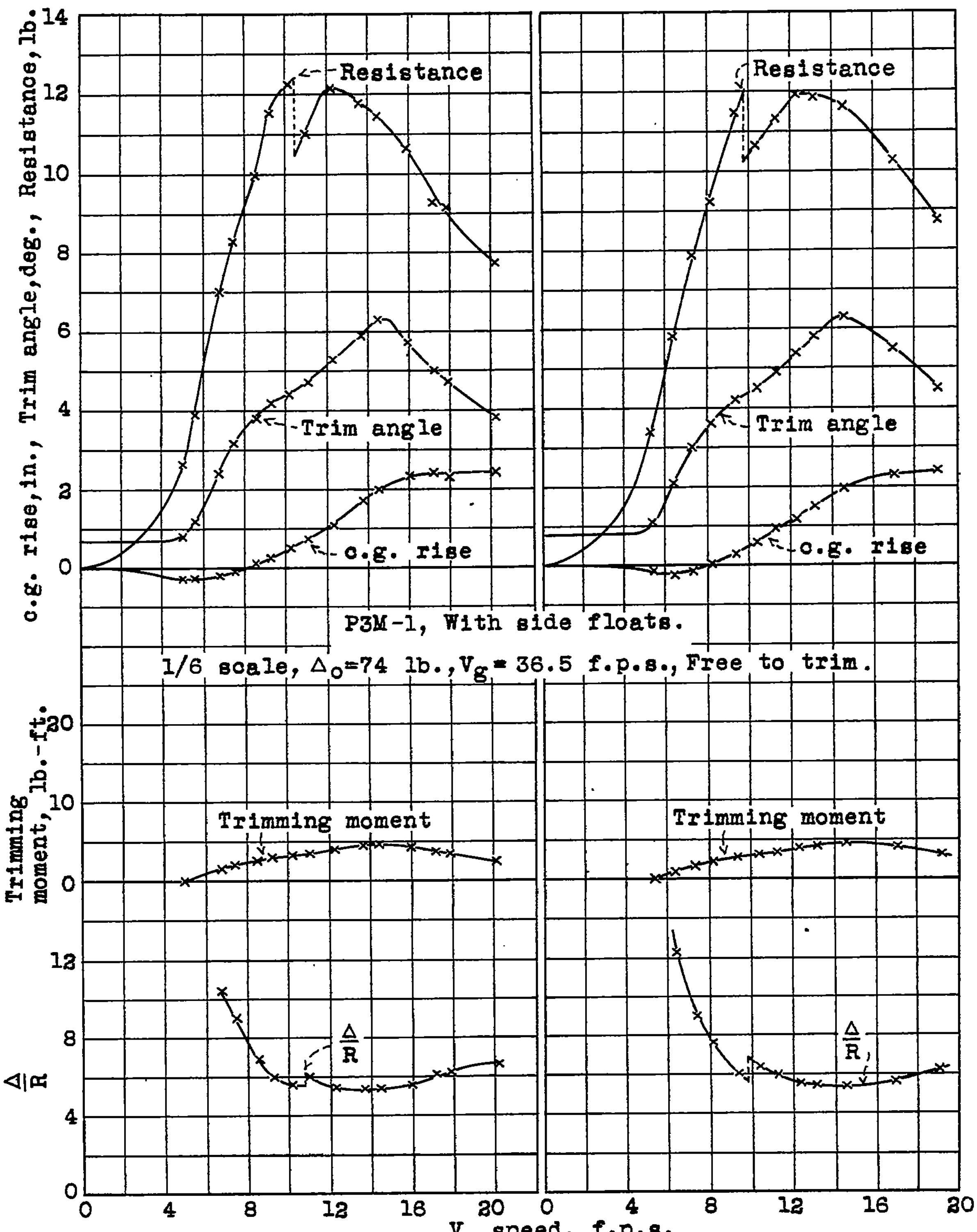


Figure 11.- Water characteristics of model 18-SA1. with spray strip A1.

Figure 12.- Water characteristics of model 18-SA. with spray strip A.